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Parasites of Fishes of Oahe and Big Bend Reservoirs, South Dakota

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PARASITES OF FISHES OF OAHE AND BIG BEND RESERVOIRS, SOUTH DAKOTA

BY

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PARASITES OF FISHES OF OAHE AND BIG BEND

RESERVOIRS, SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

_______________________ June 1, 1965
Thesis Adviser Date

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Head, Entomology-Zoology Department Date

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INTRODUCTION

During the summer and fall of 1964, 292 fishes collected from Oahe and Big Bend Reservoirs in central South Dakota were examined for parasites. Sixty-five percent of the 18 different species of fishes examined were parasitized by at least one of the 16 species of parasites found. Seventy-five percent of the 162 fishes examined from Oahe Reservoir were found to be infected with at least one species of parasite, and 54 percent of the 130 fishes examined from Big Bend Reservoir were infected.

Tables I and II summarize the data giving the kinds and numbers of fishes infected, the kinds of parasites causing the infection, the location of the parasite in the host, and some identifying characteristics of the parasites. The fishes found to be harboring the largest number of species of parasites were the black bullheads and the yellow perch. Perhaps one reason for this is that there were more black bullheads and yellow perch examined than any other species. Another reason could be that the conditions present in the reservoirs are best suited for the life cycles of the parasites infecting the bullheads and perch.

The purpose of this study is to determine the most prevalent fish parasites occurring in the Oahe and Big Bend Reservoirs. A comparison is made between the parasites found in Oahe and those found in Big Bend, and also between the seasonal differences of parasitism in some species of fishes found in both reservoirs.

REVIEW OF LITERATURE

Mueller and Van Cleave (1932, 1934) conducted the first comprehensive study on parasites of fresh-water fishes in the United States. One of the chief aims of this survey was to present an overall view of the biology and ecology of the parasites of fishes in a single lake, which was Oneida Lake in New York. During the course of this study many new host records were discovered and many new species and genera of parasites were described.

Other early studies were done on the Mohawk-Hudson Watershed in New York by Hunter and Hunter (1935) to learn more about the yellow and black grub parasites of fish. The investigators found that the larvae most frequently encountered in this study were those belonging to the Family Strigeidae. A study to compare the parasite infestation of northern pike and pickerel of Lake Pacotopaug in Connecticut with infestations of the same species from other localities was conducted by Hunter and Rankin (1939).

Meyer (1954), another important investigator in the eastern states, examined fishes taken from 30 different lakes and ponds throughout Maine. The author reported the species of parasites found and also described their life cycles. Bangham (1954) conducted various surveys throughout this country and also in Canada. One study done by Bangham and Adams (1954) involved the examination of numerous fishes taken from many different lakes and streams in British Columbia.

Midwestern investigators contributed much to the knowledge of fish parasites in their own area of the country. Fischthal (1944-1947) did extensive studies on the parasites of northwest Wisconsin fishes. The specimens for this study were obtained from various ponds, rivers, lakes and streams in northwestern Wisconsin. Before the work of Fischthal (1944-1947) there had been little work done on fish parasites in Wisconsin. More recently Anthony (1963) examined fishes from 17 different lakes and ponds throughout Wisconsin.

Two surveys were conducted in Kansas by Wilson (1957, 1961). The fishes examined in both studies were taken from Leavenworth County State Lake. In both surveys the author found that 66 percent of the fishes were infected with some kind of parasite.

Fishes from Hemig Lake and two adjacent lakes in Michigan were examined for parasites by Lawler and Watson (1958) during a limnological study of the lake. In northwestern Minnesota, new distribution records were determined for helminths of fishes from Basswood Lake by Odlaug, Arseneau and Brownell (1962).

"Grubby" or "wormy" fishes taken by anglers in Trumbull Lake, Clay County, Iowa, prompted a detailed study by Meyer (1958) of the parasite fauna of fishes in this area. Work was begun in the summer of 1954 and collections were made intermittently throughout the summers of 1954 and 1955.

In Kansas, catfishes were studied by Harms (1959, 1960) in two different surveys. The first study involved parasitism of 124 out of

135 catfishes collected from various localities in northeastern Kansas. During his second study, the author concluded that the degree of parasitism of catfishes was affected more by the ecological habitat of the host than by the size of the host.

The first known fish parasite survey in North Dakota was done during the summers of 1951 and 1952 by Hoffman (1953). The fishes for the study were collected from the Turtle River near Arvilla, North Dakota. A total of 195 fishes belonging to 9 species were examined and 92 percent were found to be infected with at least one species of parasite. Hoffman (1953) did another study to determine the occurrence of <u>Ornithodiplostomum ptychocheilus</u>, a trematode, in fishes of Turtle River. During this examination the author found the metacercariae of this trematode in four new hosts.

The first extensive investigation of the parasites of fishes in South Dakota was conducted by Hugghins (1959). The specimens examined were collected mostly from lakes and streams in different parts of South Dakota. Relatively few fishes were taken from the Missouri River system. A total of 589 fishes of 28 different species were examined by the author. Of the fishes examined, 76 percent were found to be parasitized by at least one of the 35 different species of parasites found.

Zischke and Vaughn (1962) conducted the first known study of the parasites of fishes of the Missouri River reservoir system. In this survey the authors wanted to determine the incidence and distribution of helminth infection among young-of-the-year fishes common in Fort Randall Reservoir, South Dakota. It was found that young fishes in the reservoir, because of feeding habits and environmental conditions, begin to build up a population of parasitic helminths very early in their lives.

Russian investigators have pioneered in the area of changes in the parasite fauna of fishes correlated with the creation of impoundments in river systems. Dogiel, Petrushevski, and Polyanski (1961) summarized the findings in this area:

> 1. The original fish parasite fauna of newly constructed reservoirs is of the river type, since it comprises fish parasites of the flooded sectors of the river and other waters included in the reservoir. During the first years of the reservoir's existence, however, considerable changes occur in the fish parasite fauna, extending over a considerable period of time (not less than 10-15 years). These changes vary for different groups of parasites, depending on the type of life cycle and on the hydrobiological changes taking place in the reservoir.
>
> 2. The considerable lowering of the abundance directly after flooding of the reservoir, with the subsequent rise, can be observed for the majority of parasites with indirect life cycle as well as for the parasitic copepods. For the latter and for many cestodes the period of low abundance is relatively short, extending over 1-2 years. It is longer for the trematodes (4-5 years).
>
> 3. The formation of the fish parasite fauna is affected by the geographical position of the reservoir. Thermophilic species, rapidly developing in high temperatures, reach high abundance in the south, but are suppressed and reach only low abundance in the north. On the other hand, the cold-loving species find more favorable living conditions and become more abundant in the north.
>
> 4. The parasite fauna of the large reservoirs is not uniform throughout their entire area. Near the dam it bears a

resemblance to the fauna of sluggish waters, while in the upstream area it tends to preserve the character of the fauna of the parental stream.

5. Among the diseases most dangerous to the reservoir fisheries are ligulosis (south and temperate zones), copepod infestations (mainly south), the black spot disease*(south) and triaenophorosis (north and temperate zones).

*Infestations with the trematode, Neascus cuticola. (Translator's note)

Stolyarov (1961, 1962) found that the parasite fauna of fishes in most of the reservoirs he examined in Russia consist of parasites which were inhabitants of the rivers and streams before the reservoirs were impounded. During the first and second years of impoundment, the author found that the number of species of parasites was found to be fewer in the reservoirs than the number present in rivers which were adjacent to the reservoirs. Parasites with a direct life cycle were found to develop and spread most rapidly while those with complex life cycles were found to develop only if there were reestablishment of their intermediate hosts. The author concluded that the parasite disease of fish in reservoirs is characteristically localized, and that the range of host species infected by parasites in reservoirs was significantly lower than that found in adjacent rivers.

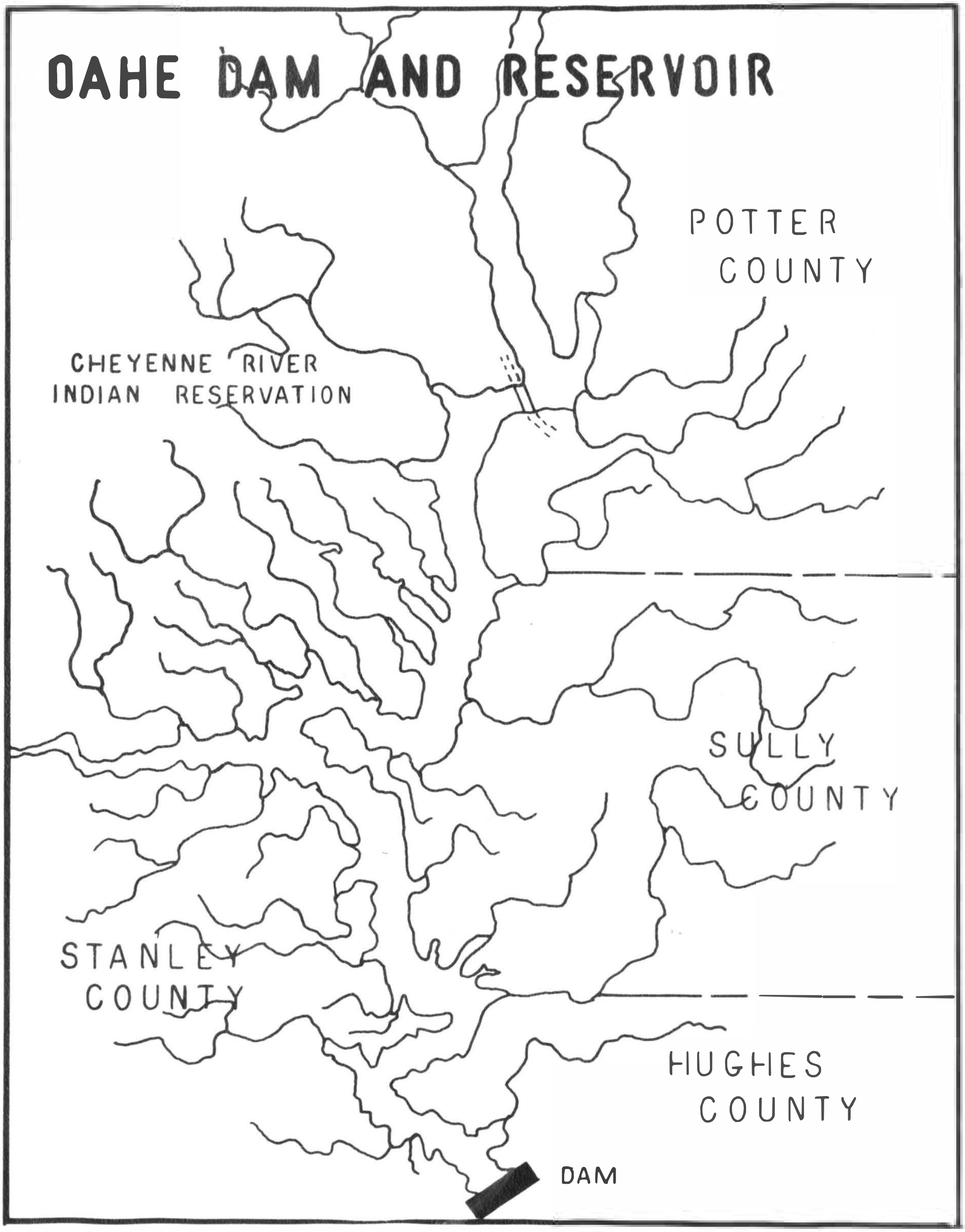
Several studies have been done on the parasites of fishes of the Rybinsk Reservoir in Russia by Izyumova (1959). Other Russians who have done important fish parasite studies are Smirnova (1959), Romanova (1957), Sharapova (1963), and Didorova (1959).

DESCRIPTION OF THE RESERVOIRS

Oahe Dam and Reservoir

Oahe Dam is located six miles northwest of Pierre, South Dakota, on the Missouri River. Construction of the dam started in September, 1948, and the dam was officially closed on July 31, 1958. With this closure and the subsequent filling of the reservoir, Oahe became the third and largest impoundment on the Missouri River in South Dakota. The reservoir when full extends upstream from the dam approximately 250 miles, almost reaching Bismarck, North Dakota. The maximum depth of the lake is about 200 feet near the dam and it has a surface area of 376,000 acres. The dam has a maximum storage capacity of 23,600,000 acre-feet, which is more than the normal flow of the Missouri River past Sioux City, Iowa, in one year.

Oahe Dam is the largest rolled earth dam in the world. It is 9,300 feet long and 242 feet high. The dam is made up of 90,000,000 cubic yards of shale and earth which were excavated in the vicinity. Oahe Reservoir was constructed by the Corps of Engineers for the multiple purposes of flood control, production of hydroelectric power, irrigation and maintenance of downstream flow. With the development of access roads and recreation spots the reservoir will play an important role in the outdoor, boating, and fishing enthusiasts' summer time recreation. There is an ample variety of fishes to be caught by the many fishermen who flock to Oahe from various areas throughout the state and from other states.


OAHE DAM AND RESERVOIR
POTTER COUNTY
CHEYENNE RIVER INDIAN RESERVATION
SULLY COUNTY
STANLEY COUNTY
HUGHES COUNTY
DAM

Oahe Dam is one of the major main stem units of the comprehensive plan of development of the Missouri River Basin, more widely known as the Pick-Sloan Plan. This plan was authorized by Congress in the Flood Control Act of 1944.

Relative species composition of fishes of Oahe Reservoir was studied by Fogle (1961, 1963). During the second year of impoundment he found that rough fishes such as gar, goldeye, suckers, buffalo, carp, stonecat, and drum were most numerous in net catches. Together these fishes were found to comprise 95.6 percent by number of the frame net catches and 85.2 percent by number of the gill net catches.

During the third year of impoundment of the reservoir, Fogel found a notable decrease in the catch of rough fishes. They comprised 93 percent by number of the frame net catches and 63 percent by number of the gill net catches. Bigmouth buffalo was one exception, showing a large population increase. Certain game fishes such as northern pike, yellow perch, black crappie, and white crappie showed an increase. They comprised 7 percent of the frame net catches by number and 37 percent of the gill net catches by number. This was compared to 4 percent and 15 percent the previous year. Northern pike were showing good growth and reproduction and were predicted to become one of the major game fishes in the reservoir.

During the fourth year of impoundment carp was found to be the only rough fish to show a decline in numbers from the previous year. Game fishes showed a noticeable increase over the previous year mainly because of the increase in numbers of yellow perch, sauger, black crappie, and white crappie. During the fifth year of impoundment of the reservoir, it was found that rough fishes made up a smaller percentage of the year's catch than in the previous season. They were found to comprise 65 percent by number of the frame net catches and 31 percent by number of the gill net catches. These percentages are compared with 71 percent and 56 percent during the previous season. The increase in the numbers of game fishes was attributed mainly to the increase in the yellow perch population. Most of the other game fishes were found to be present in about the same numbers as in the previous season. The northern pike was reported to have had good growth and reproduction again during the fifth year of impoundment.

The distribution of most species of fishes was reported to be quite even throughout most of the reservoir. Habitat was thought to have some effect on local fish populations. For example, it was found that crappies, bluegills, and yellow perch were attracted to shallow, brushy areas while sauger and sturgeon were attracted to the open and deeper water. Aside from these species, all other species were found to be common in all parts of the reservoir.

In addition to the distribution studies, Fogle also conducted two tagging studies. In the first study, 192 northern pike were netted and tagged at Okobojo Creek, which flows into the Oahe Reservoir. The tagged fish were recovered as far upstream as the tailwaters of

Garrison Dam in North Dakota and as far downstream as the dam impounding Oahe. This study shows that the northern pike are capable of traveling great distances. In the other tagging study, various species of fishes were tagged in the tailwaters of Oahe and some were picked up as far away as Fort Randall Reservoir before Big Bend Dam was closed off. This again shows that most of the species in the reservoirs are capable of moving great distances.

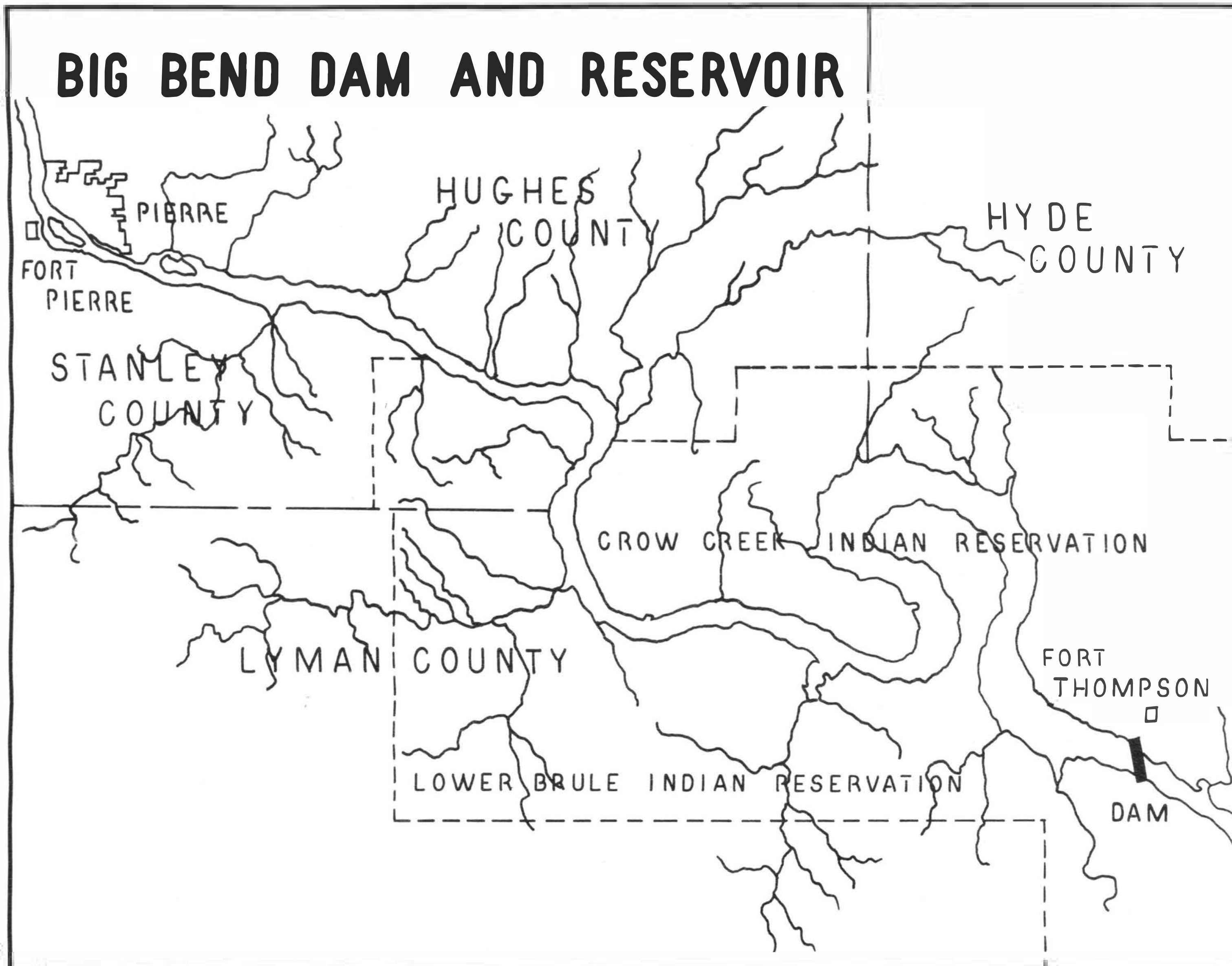
Big Bend Dam and Reservoir

Big Bend Dam is located on the Missouri River 21 miles upstream from Chamberlain, South Dakota, and 84 miles downstream from Pierre, South Dakota.

The embankment is of the rolled earth type and contains 17,000,000 cubic yards of shale and chalk fill. The top of the dam is 100 feet above the bed of the river. It is 50 feet wide at the top and 1,200 feet wide at the bottom.

The reservoir at normal level will store 1,900,000 acre-feet of water. The shoreline level will fluctuate only a few feet with planned normal operation. The reservoir will extend approximately 80 miles upstream with its headwaters near Pierre, South Dakota. The shoreline length will be about 200 miles and the water surface area will be 55,000 acres.

With the closure of the Big Bend Dam in July of 1963, the fourth impoundment on the Missouri River in South Dakota was created.


BIG BEND DAM AND RESERVOIR
PIERRE
FORT PIERRE
HUGHES COUNTY
HYDE COUNTY
STANLEY COUNTY
CROW CREEK INDIAN RESERVATION
LYMAN COUNTY
FORT THOMPSON
LOWER BRULE INDIAN RESERVATION
DAM

It is expected that this reservoir will afford excellent opportunities for aquatic recreation to people living in the plains region.

Access will be provided to public use areas on both Oahe and Big Bend Reservoirs. The facilities will include access roads, camp sites, boat launching facilities, swimming beaches, trailer parking areas, fireplaces, picnic tables, and shade shelters. The facilities on both reservoirs will be developed in cooperation with the U. S. Fish and Wildlife Service, the National Park Service, the Bureau of Indian Affairs, and the South Dakota Department of Game, Fish and Parks.

To date no studies of species composition and distribution have been conducted on the fishes of Big Bend Reservoir. It is probable that the species composition and distribution of Big Bend Reservoir will closely resemble that of Oahe Reservoir. All species of fishes in both reservoirs have been reproducing at a sufficient rate to populate the reservoirs, thus eliminating the need for stocking fishes.

PROCEDURE AND METHODS

The fishes taken from Oahe Reservoir were netted with fyke nets and modified fyke nets in the vicinity of Whitlock Crossing. The fishes taken from Big Bend Reservoir were taken with a trawl downstream from Pierre, South Dakota.

Immediately after the specimens were taken from the nets they were placed in styrofoam ice chests to keep them cool and to prevent spoiling. Later they were placed in plastic bags and refrigerated until the time of examination. The plastic bags prevented the specimens from drying out.

The examination of the fishes consisted of first examining the external surface of the body and the gills for ectoparasites. Parasitic copepods were placed in 70 percent alcohol in vials and stored this way. Leeches were fixed in 10 percent formalin and left in the same for storage. The flesh was examined for encysted metacercariae, which were fixed in F.A.A. (Formalin Alcohol Acetic Acid) and then stored in 70 percent alcohol.

Next the body cavity was opened from anus to isthmus. The body cavity and viscera were examined for nematodes and plerocercoids of cestodes. The liver was also checked for metacercariae of trematodes and plerocercoids of cestodes. The nematodes which were found were killed in 10 percent formalin and stored in vials of the same. Plerocercoid larvae were fixed in F.A.A. and stored in 70 percent alcohol. The swim bladder was also checked for parasites.

The digestive tract was then removed from the body cavity and placed in a black tray for examination. If the digestive tract was long, it was cut into sections for examination. The reason for using the black tray was so that the parasites would show up against the dark background. After the gut was opened and a preliminary examination was made, the contents of the gut were scraped out and the mucosa was washed. Water was then decanted from the tray and fresh water was added to make the parasites in the sediment in the bottom of the tray much more visible.

Tapeworms were killed in a relaxed condition by dropping them into hot water. To keep them flat while fixing them, the tapeworms were wrapped around a glass slide and placed in a petri dish and flooded with F.A.A. After an hour in the F.A.A. the tapeworms could be unwound from the slide and placed in 70 percent alcohol in a vial for storage.

Nematodes were fixed in 10 percent formalin and stored in the same. For clearing they were transferred to a mixture of 90 parts 70 percent alcohol and 10 parts glycerine. The caps were left off the vials and the 70 percent alcohol was allowed to slowly evaporate leaving the nematodes in pure glycerine. The worms were mounted in the glycerine for examination.

The Acanthocephalans were fixed and stored in 10 percent formalin and were later transferred to 70 percent alcohol for storage.

Before discarding the fish carcass a few slices were made in the flesh to check for encysted plerocercoids and metacercariae.

Host-record sheets were used in recording the data. Each fish examined was given a number. Other information listed on the sheet included the common and scientific name of the fish, the date, the total length, the sex, the source of the specimen, the parasites found and their location in the host. Organs examined and found negative were also listed.

A strip of paper containing the host number, the name of the fish, the date, and the location from which the fish was taken was included in each storage vial along with the parasites found. If more than one kind of parasite was found in one fish, the parasites were numbered 1a, 1b, 1c, etc., with the corresponding numbers on the host-record sheet and were then placed in separate vials for storage.

Harris hematoxylin (an aqueous stain) and aceto-carmine (an alcoholic stain) were used in staining the parasites. In using the water stain, the specimens were taken from the 70 percent alcohol and placed first in 35 percent alcohol, then into distilled water to which a small amount of Harris hematoxylin was added to make a dilute stain. The specimens were left for several hours or over night in the stain. Next they were dehydrated in 35 percent alcohol and then in 70 percent alcohol. Destaining was accomplished by adding a mixture of 70 percent alcohol and HCL until wisps of stain drifted from the specimens.

After the destaining process, the specimens were placed in fresh 70 percent alcohol to stop the destaining (2 changes). Complete dehydration was accomplished by running the specimens through 85 percent alcohol, 95 percent alcohol, and absolute alcohol (at least 2 changes). With the aceto-carmine alcoholic stain, the specimens were taken from the storage vial containing 70 percent alcohol and put directly into 70 percent alcohol for staining. Again the specimens were left in the dilute stain preferably overnight. Destaining was accomplished as outlined above.

After the specimens had passed through two changes of absolute alcohol they were ready for clearing. First they were transferred to a solution containing half absolute alcohol and half xylol and finally to pure xylol for the final step in clearing. The specimens to be mounted were transferred quickly from the xylol to a few drops of mounting medium on a glass slide and a glass cover slip was applied. It has been found that if a film of xylol is applied to the underside of the cover slip, the mounting medium will spread out under the cover slip much more readily. On this project a commercial mounting medium called Permount was used and found to be very satisfactory. The process of transferring the specimens from the xylol to the mounting medium was done very quickly since the specimens would turn black if left in the air too long.

DISCUSSION

Cestodes

The tapeworms were found to be the most abundant parasites in fishes examined from Oahe and Big Bend reservoirs. They are in the Phylum Platyhelminthes, Class Cestoidea. The body of the tapeworm is usually long and slender and is made up of numerous flat segments called proglottids, each of which contains both male and female reproductive organs. A few of the more primitive tapeworms have an elongate nonsegmented body with only one set of reproductive organs. A tiny head called the scolex is located at the anterior end of the body and serves as a means of attachment to the lining of the intestine of the final host. The tapeworm is an obligate parasite, since it has no digestive system of its own and lives only by absorbing food from the intestine of the final host.

Proteocephalus pinguis La Rue, 1911, is a tapeworm which was found in northern pike in both Oahe and Big Bend reservoirs. The rate of infection was nearly 100 percent in fish taken from both sources. Mueller and Van Cleave (1932), Hugghins (1959), and Odlaug, Arseneau and Brownell (1962) all have reported similar findings of this parasite in northern pike.

The adult tapeworm is easily distinguished by its small body and broad, flat scolex with five suckers. One of the five suckers is apical in position, located directly at the end of the scolex. The

Fishes Examined For Parasites

Table I

Common Name	Scientific Name	No. Fish Examined	No. Fish Infected	Source Of Fish	Parasites Found Species
Yellow perch	*Perca flavescens*	45	41	Oahe	*Proteocephalus ambloplitis* plerocercoids *Proteocephalus sp.* *Bothriocephalus cuspidatus*
		15	6	Big Bend	*Glaridacris catostomi*
Freshwater drum	*Aplodinotus grunniens*	2	2	Oahe	*Proteocephalus ambloplitis* plerocercoids
		2	0	Big Bend	
Carp	*Cyprinus carpio*	13	3	Oahe	*Glaridacris confusus*
		15	7	Big Bend	*Neoechinorhynchus cylindratus*
Sauger	*Stizostedion canadense*	1	0	Oahe	*Bothriocephalus cuspidatus*
		1	1	Big Bend	
Goldeye	*Hiodon alosoides*	21	19	Oahe	*Bothriocephalus cuspidatus*
		7	6	Big Bend	
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	1	0	Oahe	
		1	1	Big Bend	*Proteocephalus sp.*
Northern redhorse sucker	*Moxostoma macrolepidotum*	1	0	Big Bend	*Proteocephalus sp.*
Blue sucker	*Cycleptus elongatus*	2	1	Big Bend	*Helobdella sp.*
Shortnose gar	*Lepisosteus platostomus*	1	1	Big Bend	*Proteocephalus sp.*

Fishes Examined For Parasites

Table I

Common Name	Scientific Name	No. Fish Examined	No. Fish Infected	Source Of Fish	Parasites Found Species
Whitefish	Coregonus clupeaformis	1	0	Big Bend	
Northern pike	Esox lucius	10	10	Oahe	Proteocephalus pinguis
		2	1	Big Bend	
Bigmouth buffalo	Ictiobus cyprinellus	5	2	Big Bend	Camallanus oxycephalus
		5	2	Oahe	Lissorchis fairporti
Smallmouth buffalo	Ictiobus bubalus	4	2	Oahe	Glaridacris confusus
		5	1	Big Bend	Camallanus oxycephalus
					Neoechinorhynchus cylindratus
Black bullhead	Ictaluris melas	24	24	Oahe	Proteocephalus amboplitis plerocercoids
					Proteocephalos sp. plerocercoi
					Corallobothrium fimbriatum
		34	22	Big Bend	Proteocephalus sp.
					Lernaea cyprinacea
					Dacnitoides robusta
					Hysteromorpha triloba
Channel catfish	Ictaluris Punctatus	4	3	Oahe	Proteocephalus amboplitis plerocercoids
					Corallobothrium fimbriatum
		4	2	Big Bend	Proteocephalus sp.

adult tapeworms were found in the intestine of the definitive host and were fairly numerous, but they did not seem to be causing the fish any evident harm.

The first step in the life cycle of P. pinguis involves the passing of the gravid proglottids containing the eggs from the intestine of the host into the water. The eggs with fully developed onchosphere drifts about in the water until eaten by a copepod. The egg hatches in the intestine of the copepod, and the onchosphere migrates into the haemocoele where it develops into the procercoid larva. When these infected copepods are eaten by a fish which can serve as the second intermediate host, the procercoid larva migrate through the intestine and into the coelom where it develops into the plerocercoid larva, which is the infective larval stage. The final stage in the life cycle takes place when a fish containing the infective plerocercoid larva is eaten by the proper definitive host (in this case northern pike) in which the adult tapeworm develops. A possible reason for the high rate of infection of this tapeworm in both reservoirs is that the intermediate hosts necessary for the completion of the life cycle are present in great numbers.

Proteocephalus ambloplitis plerocercoids were found in several species of fishes from Oahe and Big Bend Reservoirs. The majority of these larval forms were found in the liver, mesenteries and ovaries. The species of fishes from Oahe found to be harboring the plerocercoids were black bullhead, yellow perch, freshwater drum, channel catfish, and black crappie. The plerocercoids were most numerous in the livers and mesenteries of black bullheads and yellow perch. In Big Bend Reservoir the only fishes infected were black bullheads and yellow perch. Wilson (1957) reported heavy infections of this larval form from fishes of Kansas, and Hugghins (1959) reported its occurrence in black bullheads taken from various lakes in South Dakota, but found only one adult *P. ambloplitis* in a bass taken from Lake Mina, South Dakota.

The *P. ambloplitis* plerocercoid is differentiated from all the other proteocephalid plerocercoids by a dark-staining vestigial fifth sucker. This sucker is posterior to the other four suckers during the earlier stages of development and moves forward to the level of the other suckers when the scolex is evaginated. The vestigial sucker persists even into adulthood but is never functional. The four functional suckers are much larger than most of those found in this genus.

The life cycle of *P. ambloplitis* is very similar to that of *P. pinguis* in that it has the procercoid larva in a copepod and the plerocercoid larva in a fish. According to Olsen (1962), if young fish harboring the immature plerocercoids are eaten by a larger fish, the parasites are unable to develop to sexual maturity and will migrate to the coelom again, frequently invading the gonads. The infected gonads are usually destroyed, resulting in sterile fish. This may be an important factor in reducing fish populations if the rate of infection is high. Very few of the plerocercoids recovered in Oahe and Big Bend were found in the gonads; most of them were found in the liver or mesenteries of the intestine. When a bass or other suitable definitive host eats a fish containing the mature plerocercoids, the adult tapeworm will then develop.

Bass, which are the normal definitive host for this parasite, are not numerous in Oahe and Big Bend Reservoirs and were not picked up in either of the summer netting projects. It is possible that the reason for the heavy rate of infection of *P. amblopIitis* plerocercoids is that the intermediate host can be one of many different fishes. A majority of these plerocercoids perhaps never reach the definitive host but remain in the intermediate host indefinitely.

Corallobothrium fimbriatum Essex, 1927, had a low incidence in black bullheads from Oahe and Big Bend Reservoirs, 4 percent and 12 percent respectively. In the channel catfish a high incidence of 75 percent was found in Oahe Reservoir but none were observed in channel catfish examined from Big Bend Reservoir. All of the tapeworms of this species found in this study were located either in the stomach or the intestine of the host. Mueller and Van Cleave (1934) reported the sparse occurrence of this tapeworm in the intestine of channel catfish. Haderlie (1953) also reported this species from brown bullheads in California.

This genus is distinguished from other proteocephalids by having many characteristic folds or lappets of tissue surrounding the four large suckers. The life cycle of *C. fimbriatum* has been described by Essex. The life cycle may involve either a single intermediate host, a copepod, or two intermediate hosts, a copepod and a fish. The eggs which are passed into the water with the feces of the definitive host, must first be eaten by the copepod. Within 14 days an infective plerocercoid larva will develop in the body of the copepod, and the first intermediate host is infective. If, however, the copepod is eaten by a fish which can serve as a second intermediate host, the definitive host will develop the infection by eating the second intermediate host containing the infective plerocercoid larva.

An unidentified species of *Proteocephalus* was found to occur in a number of fishes from Big Bend Reservoir, as follows: yellow perch, black bullhead, shovelnose sturgeon, black crappie, white crappie, goldeye, channel catfish, and shortnose gar. In Oahe Reservoir, only one fish, a black bullhead, was infected. The fifth or apical sucker was lacking in these tapeworms. It is not unusual to find proteocephalids which are very difficult to identify as to species. For example, Haderlie (1953) reported difficulty in classifying proteocephalids of fresh-water fishes of California. This group of tapeworms is extremely widespread and abundant in fresh-water fishes, and many of the dozens of species which have been described do not have clear-cut specific characters. Wardle and McLeod (1952) have attempted to resolve some of the taxonomic confusion by organizing the proteocephalids into several "species groups."

Glaridacris confusus Hunter, 1929, is a tapeworm which was found in 23 percent of the carp and in 25 percent of the smallmouth buffalo examined from Oahe Reservoir, and in 40 percent of the carp and none of the smallmouth buffalo examined from Big Bend Reservoir. *Glaridacris catostomi* Cooper, 1920, was found in only one yellow perch examined from Big Bend Reservoir. All of these parasites were found either in the stomach or intestine. Mackiewicz (1962) has described the distribution of *G. catostomi*, and Mueller and Van Cleave (1934) have mentioned both *G. confusus* and *G. catostomi* in their study.

These tapeworms are nonsegmented and have only one set of reproductive organs. *G. confusus* has a broad scolex and a short, thick neck, while *G. catostomi* has a distinctly longer and narrower neck. A further difference is that in *G. confusus* the testes and vitellaria begin at the same level anteriorly, while in *G. catostomi* the vitellaria precede the testes.

According to Olsen (1962), the life cycle of this genus involves first of all the eggs being eaten by an annelid after they are passed into the water. Next, a 6 hooked, unciliated coracidium develops from the egg and burrows through the intestinal wall of the annelid into the coelomic cavity where it develops into a tailed procercoid. Infection of the definitive host occurs when an infected annelid is eaten and the procercoid larva becomes first a plerocercoid larva and then an adult. Perhaps a fairly low rate of infection with

Parasites Found In Fishes

Table II

Kind Of Par.	Name Of Par.	Fish Host	Site In Fish	No. Inf. Oahe	No. Inf. B.B.	No. Exam. Oahe	No. Exam. B.B.	Recognition Feature
Tapeworm (Cestoda)	*Proteocephalus pinguis*	Northern pike	Intestine	10	1	10	2	Rather small tape-worm with broad scolex bearing five small suckers
	Proteocephalus ambloplitis plerocercoids	Black bullhead	Liver, mesenteries, ovaries	24	6	24	34	Very small white worms no proglottids and scolex has 4 small suckers and 1 larger dark staining sucker
		Yellow perch		45	1	45	15	
		Freshwater drum		2	0	2	2	
		Channel catfish		3	0	4	4	
		Black crappie		2	0	30	20	
	Corallobothrium fimbriatum	Black bullhead	Stomach, intestine	1	4	24	34	Scolex has 4 suckers irregular folds and lappets of tissue enclose suckers
		Channel catfish		3	0	4	4	
	Bothriocephalus cuspidatus	Goldeye	Stomach, intestinal caeca, intestine	19	6	21	7	Rectangular-shaped elongated scolex bearing two weakly developed sucking grooves
		Sauger		0	1	1	1	
		Walleye		1	1	2	1	
	Proteocephalus sp.	Yellow perch	Stomach, intestine	0	6	45	15	Small worms with four distinct suckers and a short body, few proglottids
		Black bullhead		1	8	24	34	
		Shovelnose sturgeon		0	1	1	1	
		Black crappie		0	1	30	20	
		White crappie		0	3	0	13	
		Goldeye		0	2	21	7	
		Channel catfish		0	1	4	4	
		Shortnose gar		0	1	0	1	

Parasites Found In Fishes

Table II

Kind Of Par.	Name Of Par.	Fish Host	Site In Fish	No. Inf. Oahe	No. Inf. B.B.	No. Exam. Oahe	No. Exam. B.B.	Recognition Feature
	Glaridacris confusus	Carp	Intestine	3	6	13	15	Neck is broad and short, testes and vitellaria begin at same level
		Smallmouth buffalo		1	0	4	5	
	Glaridacris catostomi	Yellow perch	Stomach	0	1	45	15	Neck is long and slender vitellaria precede the testes
Roundworms (Nematoda)	*Camallanus oxycephalus*	Black crappie	Intestine	15	2	30	20	Small red nematode with distinctive chitinous jaws
		Bigmouth buffalo		1	1	5	2	
		Smallmouth buffalo		1	0	4	5	
	Contracaecum spiculigerum	Black crappie	Mesenteries	2	2	30	20	Stout white worms
	Dacnitoides robusta			0	1	24	34	Short spicules, no ventral sucker, cuticular thickening
Leech (Hirudinea)	*Helobdella sp.*	Blue sucker	Behind pec. fin.	0	1	0	2	Small protrusible proboscis, 1 set eyes no body constrictions
Fish lice (Copepoda)	*Lernaea cyprinacea*	Black bullhead	External body surface	0	8	24	34	Elongate body with attachment organs buried in the flesh; posterior end bearing egg sacs

Parasites Found In Fishes

Table II

Kind Of Par.	Name Of Par.	Fish Host	Site In Fish	No. Inf. Oahe	No. Inf. B.B.	No. Exam. Oahe	No. Exam. B.B.	Recognition Feature
Fish lice (Copepoda)	*Actheres amboplitis*	Black bullhead	On gill rakers	0	2	24	34	Short, thick body with two curved attachment organs resembling arms
Spiny-headed worms (Acanthocephala)	*Neoechinorhynchus cylindratus*	Carp	Intestine	0	1	13	15	Spiny attachment organ. 6 spines in each row. First row of spines much larger than others
		Smallmouth buffalo	Intestine	0	1	4	5	
Flukes (Trematoda)	*Hysteromorpha triloba*	Black bullhead	Flesh	0	1	24	34	Tiny white cysts
	Lissorchis fairporti	Bigmouth buffalo	Intestine	1	0	5	2	Large oral and ventral suckers with spines around them

this parasite is due to the lack of proper annelids in the reservoirs which are necessary for the completion of the life cycle.

The genera Glaridacris and Bothriocephalus are both members of the Order Pseudophyllidea. This order has as its major characteristic two simple sucking grooves on the scolex for attachment. Bothriocephalus cuspidatus Cooper, 1917, which was found to occur in goldeye, sauger, and walleye from Oahe and Big Bend Reservoirs, is a very striking example of this order because of its large scolex with very pronounced grooves. This parasite had a high incidence in goldeye from both reservoirs. It was also found in walleye from both reservoirs, but in only one sauger from Big Bend Reservoir. Although the number of these parasites found in each goldeye was fairly high, the fish appeared to be in good condition. These parasites were found in the stomach, intestinal caeca, and intestine. B. cuspidatus was also reported in the caeca and intestine of walleye and sauger by Hugghins (1959).

B. cuspidatus is easily identified by its elongate rectangular-shaped scolex with the two weakly developed sucking grooves and the distinct division of the body into proglottids. The larval stage of this tapeworm may also be identified by this characteristic scolex which is present but much reduced in size.

The life cycle of B. cuspidatus involves only one intermediate host which is a copepod. The eggs are passed from the body of the host with the feces into the water and are eaten by the copepod. The procercoid larvae develop within 9 or 10 days and after this initial period of development are capable of becoming established in the digestive tract of the definitive host which feeds upon the infected copepod.

Trematodes

Flukes, which are in Class Trematoda, Phylum Platyhelminthes, are classified into two orders, Monogenea and Digenea. Monogenetic flukes are ectoparasites on the gills and skin of many different fishes and have direct life cycles. In this study there were no monogenetic flukes detected. It is entirely possible that some of these flukes were present and overlooked due to their extremely small size and the fact that the fish were subjected to refrigeration for a period of time before they were examined for parasites. The flukes of the Order Digenea are endoparasites and have life cycles involving one or more intermediate hosts.

In this study, the metacercariae of Hysteromorpha triloba (Rudolphi, 1819), were taken from the flesh of bullheads collected from Big Bend Reservoir. The metacercariae appeared as tiny white cysts under the skin. The life cycle of this particular fluke was worked out by Hugghins (1954). He found that this trematode was highly specific throughout its life cycle and that the cormorant is the only final host harboring the adult fluke. Hugghins (1956a, b) found the infection of snails, which are the first intermediate host, to be heaviest in the vicinity of the cormorant nesting areas.

Another digenetic fluke, Lissorchis fairporti Magath, 1918, was found in the intestine of one bigmouth buffalo taken from Big Bend Reservoir. This fluke was originally described by Magath (1918) and the fish used in his study were buffalo from fish ponds in the vicinity of Fairport, Iowa. The fluke is described as being in the form of an elongated oval and having a large oral sucker surrounded by fleshy spines plus a large muscular ventral sucker also surrounded by fleshy spines. The life cycle involves a snail as the first intermediate host in which the cercariae develop and a chironomid larva as the second intermediate host which is infected by the cercariae that escape from the snail. The fish then is infected with the adult fluke by eating the infected chironomid.

The fluctuating levels of the shorelines of Oahe and Big Bend Reservoirs to date may have played an important role in the reduction of the number of gastropods which are necessary in the life cycle of the digenetic trematodes. With the subsequent establishment of a stable pool level in Big Bend Reservoir, an increase in the number of gastropods in the reservoir may result in an increase in the number of digenetic trematodes in future years.

Nematodes

Only three species of nematodes are reported in this study; they were not found to be as widely distributed as were the cestodes. Nematodes are members of the Class Nematoda and the Phylum

Aschelminthes. They are round, unsegmented worms with a complete digestive tract. They are dioecious, and the males are usually smaller than the females. The life cycle of these worms involves a larval stage which is characterized by having four molts, the first two of which are the only infective stages. The cuticle, the outer non-cellular protective layer of the worm, is shed with each molt.

Camallanus oxycephalus Ward and Magath, 1917, is a nematode which occurred in the intestine of 50 percent of the black crappies examined from Oahe Reservoir. The rate of infection was found to be much less in the other fishes examined. Twenty percent of the bigmouth buffalo and 25 percent of the smallmouth buffalo examined from Oahe Reservoir were also infected. In Big Bend Reservoir, 20 percent of the black crappies, 20 percent of the bigmouth buffalo, and none of the smallmouth buffalo were found to harbor this parasite. In most of the fishes examined the worms were found at the anus. It is believed that the worms normally inhabit the posterior portion of the intestine but that the refrigeration of the specimens before examination caused the worms to migrate to the anus. A similar phenomenon was observed by Hugghins (1959) in his examination of South Dakota fishes.

This particular nematode is easily recognized by the distinctive red color of the body and the chitinous jaws which are shaped like sea shells. The red color is not permanent and usually fades after the worms have been in storage for a short time.

Contracaecum spiculigerum Rudolphi, 1819, larvae were found loosely coiled in the mesenteries in the vicinity of the intestinal caeca of black crappies. The rate of infection was fairly low with 6.6 percent infected in Oahe Reservoir and 1 percent in Big Bend Reservoir. Hugghins (1959) reported finding these worms in several species of fishes from lakes in South Dakota.

This parasite is recognized by the stout white body with a very small caudal spine at the posterior tip, and by the intestinal caecum lying beside the esophogus. The adult worms are harbored in the stomachs of cormorants and pelicans and the fish are infected by eating the eggs which are dropped into the water with the feces of the infected birds.

Dacnitoides robusta Ward and Magath, 1916, was found in only one of the black crappies examined for parasites from Big Bend Reservoir. This small nematode was found coiled in the mesenteries of the intestinal caeca. The species D. robusta is recognized by a characteristic cuticular thickening at the anterior end of the body, the absence of a pre-anal sucker and the short spicules of the male. At the time of the publication of Mueller and Van Cleave (1932) the species had not been found in any host other than Ameiurus nebulosa (the yellow bullhead).

Acanthocephala

Spiny-headed worms are members of the Phylum Acanthocephala and are characterized as having an elongate, unsegmented body and a protrusible proboscis which is covered with rows of spines. These worms are dioecious and the males are usually smaller than the females. These parasites have no digestive tract and are obligate parasites all of their lives. Only one acanthocephalan was discovered in this study. Neoechinorhynchus cylindratus Van Cleave, 1913, were found in the intestine of carp and smallmouth buffalo from Big Bend Reservoir. According to Ward (1940), the proboscis of the worm has an anterior row of relatively larger spines followed by rows of much smaller spines posteriorly. Each row contains 6 spines. This parasite was reported from numerous species of fishes by Van Cleave (1934). Two intermediate hosts were shown to be involved in the life cycle. The first was an ostracod and the second a young bluegill which contained the infective encysted N. cylindratus. Immature acanthocephalans were also found in the intestine of bluegills but adults were never found there. The light rate of infection of this parasite in the reservoir may be attributed to the small numbers of either of the two necessary intermediate hosts required for the completion of the life cycle.

Copepods

Parasitic copepods are members of the Phylum Arthropoda, Class Crustacea and Subclass Copepoda. One of the most prominent features of members of this phylum is that they all possess jointed appendages of some sort. Crustaceans are largely aquatic and breathe by means of gills or through the body wall. Copepods under this classification are members of a large group of very small aquatic crustaceans called microcrustaceans. Two species of parasitic copepods were discovered in this study. Lernaea cyprinacea Linnaeus, 1758, which were the most numerous of the two species found, occurred with their anchor-like attachment organs embedded in the flesh of 29 percent of the black bullheads examined from Big Bend Reservoir. None of these parasites were found on the bullheads taken from Oahe Reservoir. L. cyprinacea were found to occur in several different species of fishes in South Dakota by Hugghins (1959). The distinguishing feature of this parasite is the anchor-like structure at the anterior end modified to attach the copepod permanently to the host. The egg sacs are located at the posterior end of the body of the female. The eggs are released into the water and hatch into free-swimming larvae called nauplii, which molt and become an advanced larval stage called copepodids. The male and female copepodids attach themselves to the gills of any fish and copulate. After copulation the male dies and the female becomes free-swimming until she attaches herself to a host where she spends the rest of her adult life.

Another parasitic copepod found to occur on black bullheads from Big Bend Reservoir was Actheres amblopliitis Kellicott, 1880, which was found on the gill rakers of the host. This parasite has a short, thick body with two curved attachment organs resembling arms. Only 5.8 percent of the black bullheads examined from Big Bend Reservoir were found to carry this parasite. Hugghins (1959) also reported this species from bullheads collected from various South Dakota lakes and streams. The female _A. amblopliti_s spends her whole life attached to the final host while the male is only attached during mating and then dies. Two egg sacs are born on the body of the female, and the nauplius larval stage is passed in the egg before it hatches. After the egg hatches, the larva must become attached to a host quickly or it will die. The parasite attaches itself usually to the gill rakers by means of the highly modified second maxillae.

Leeches

Only one leech, Phylum Annelida, Class Hirudinea, was found. This was _Helobdella_ sp. which was found attached behind the pectoral fin of a blue sucker taken from Big Bend Reservoir. The special characteristics of the genus _Helobdella_ are a small protrusible proboscis, one set of eyes and no body constrictions. Annelids are worms which have many similar segments. The digestive tract is complete, tubular and extending the length of the body. The Hirudineans have enlarged terminal suckers for locomotion and attachment. They are monoecious but still must accomplish cross-fertilization between two individuals for reproduction to occur. The young, closely resembling the adults, hatch from cocoons which are attached to some object in the water.

Observations of Seasonal Occurrences of Parasites

A seasonal difference was noted in the infection of black crappies with *Camallanus oxycephalus*. Fifty percent of the black crappies taken from Oahe Reservoir during June and July were found to harbor *C. oxycephalus*. Another group of black crappies were collected and examined in October and none of them were found to be parasitized by this nematode.

Yellow perch examined from Oahe Reservoir can be divided into three seasonal groups according to their type of infection with *Proteocephalus ambloplitis* plerocercoids. The plerocercoids found in the livers of the perch collected during June and July were lying free in the tissue with no cyst walls surrounding them. Those collected in October were found to be somewhat encysted in the liver tissue but the cysts were small and easy to tease open. The livers examined from yellow perch collected from Oahe in November revealed large fluid-filled cysts which were more difficult to open and remove the plerocercoid.

The seasonal comparison of infection of northern pike with *Proteocephalus pinguis* and goldeye with *Bothriocephalus cuspidatus* were somewhat similar. The tapeworms of both species found in northern pike and goldeye collected during the summer consisted mostly of adult worms and very few immature worms. In the specimens which were collected in the late fall, the exact opposite was found. There were numerous immature worms and very few adults found.

The rest of the parasites occurring in this study were not found in great enough numbers to make a seasonal comparison.

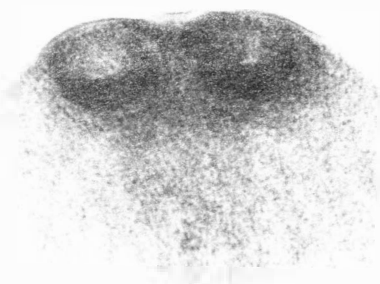


Figure I. Scolex of *Proteocephalus pinguis*

Figure II. *Proteocephalus ambloplitis* plerocercoid

Figure III. Scolex of *Bothriocephalus cuspidatus*

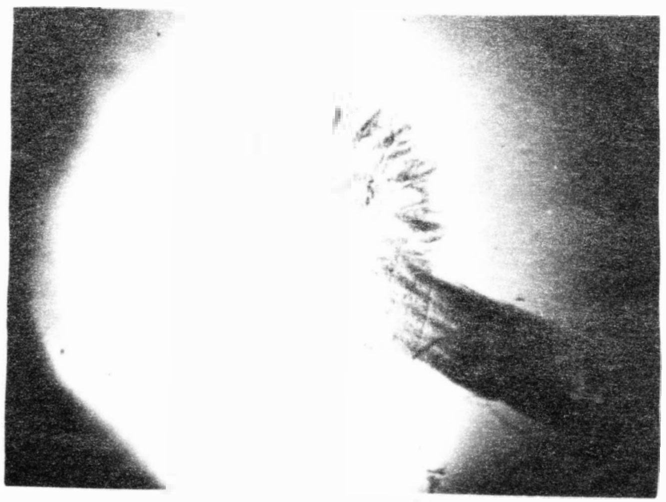


Figure IV. Scolex of *Corallobothrium fimbriatum*

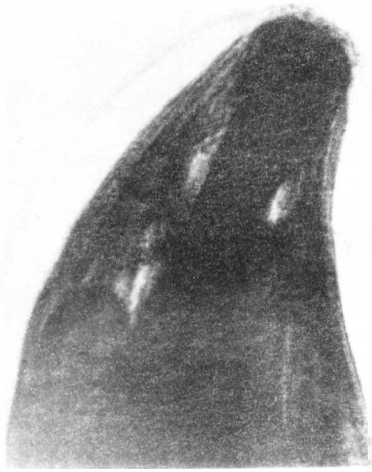


Figure V. Anterior end of Dacnitoides robusta

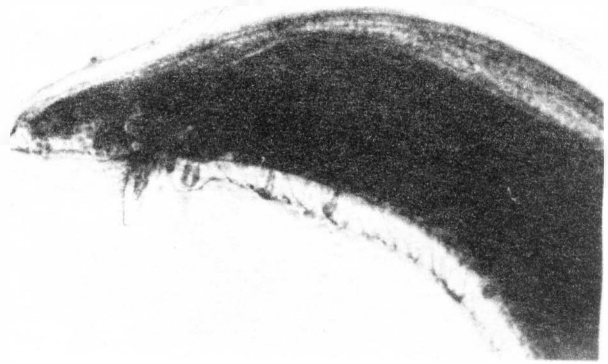


Figure VI. Posterior end of Dacnitoides robusta

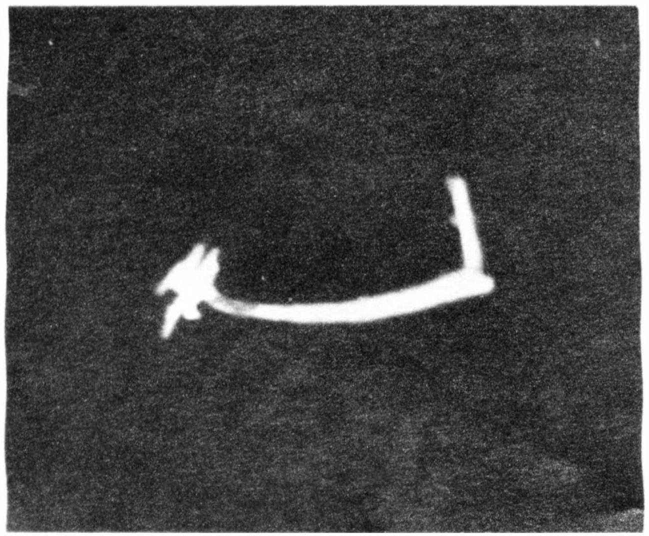


Figure VII. Lernaea cyprinacea

Figure VIII. Attachment organ of Lernaea cyprinacea

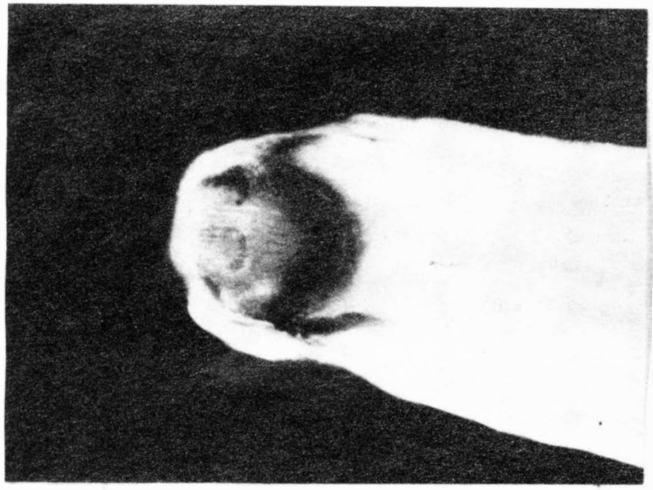


Figure IX. Jaws of *Camallanus oxycephalus*

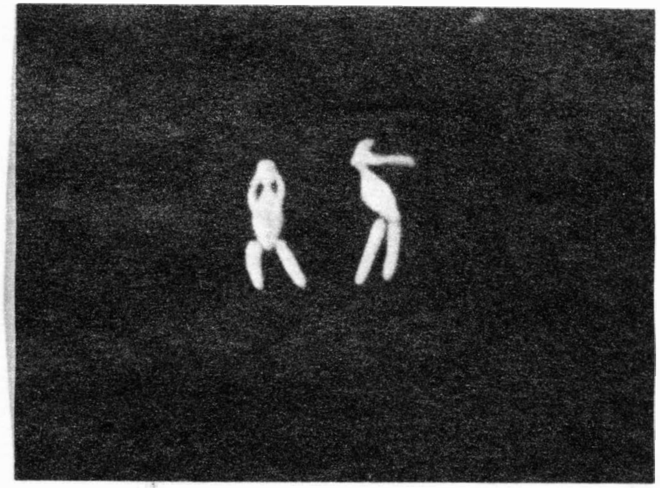


Figure X. *Actheres amblopl itis*

Figure XI. Spiny protrusible proboscis of *Neoechinorhynchus cylindratus*

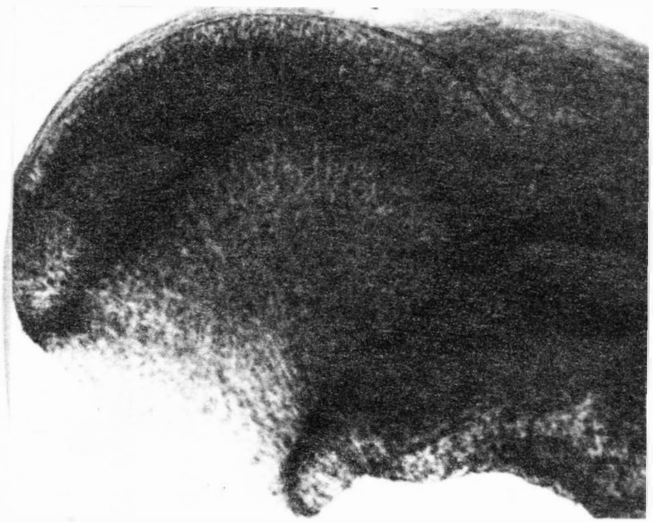


Figure XII. Oral sucker of *Lissorchis fairporti*

SUMMARY AND CONCLUSIONS

1. A total of 292 fishes from Oahe and Big Bend Reservoirs were examined for parasites. Sixty-five percent of the total number of fishes examined were found to be parasitized with at least one species of parasite.

2. Seventy-five percent of the fishes examined from Oahe Reservoir were found to be parasitized and 54 percent of those examined from Big Bend Reservoir were found to be parasitized, thus indicating a somewhat higher rate of parasitism in the fishes from Oahe Reservoir. The age difference of the reservoirs may have something to do with this difference.

3. The most heavily parasitized species of fishes were yellow perch and black bullheads. Yellow perch were found to be infected with 4 different species of parasites and black bullheads were infected with 7 different species of parasites. The fishes infected with only one species of parasite were northern pike, white crappie, walleye, shortnose gar, blue sucker, northern redhorse sucker, shovelnose sturgeon, goldeye, and sauger.

4. Cestodes comprised the majority of the parasites with 7 different species being found. Nematodes and digenetic trematodes were next in order with 3 species. There were 2 species of parasitic copepods and one leech.

5. The most numerous single parasite found in this study was the *Proteocephalus ambloplitis* plerocercoid. It occurred in 5 different species of fishes, and in 2 of these species (yellow perch and black bullhead) collected from Oahe Reservoir there was 100 percent infection of all fishes examined.

6. The proteocephalids as a group were the most widespread parasite, infecting 10 different species of fishes from Big Bend Reservoir and 7 different species of fishes from Oahe Reservoir.

7. Further studies of the parasites of fishes of Oahe and Big Bend Reservoirs should be conducted to give an overall view of the development and change of the parasitofauna in both reservoirs as they increase in age.

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